

# **SECTION 04: EXHAUST AND AFTERTREATMENT SYSTEM**

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## Section 04: EXHAUST AND AFTERTREATMENT SYSTEM

### 1. EXHAUST AFTERTREATMENT SYSTEM OVERVIEW

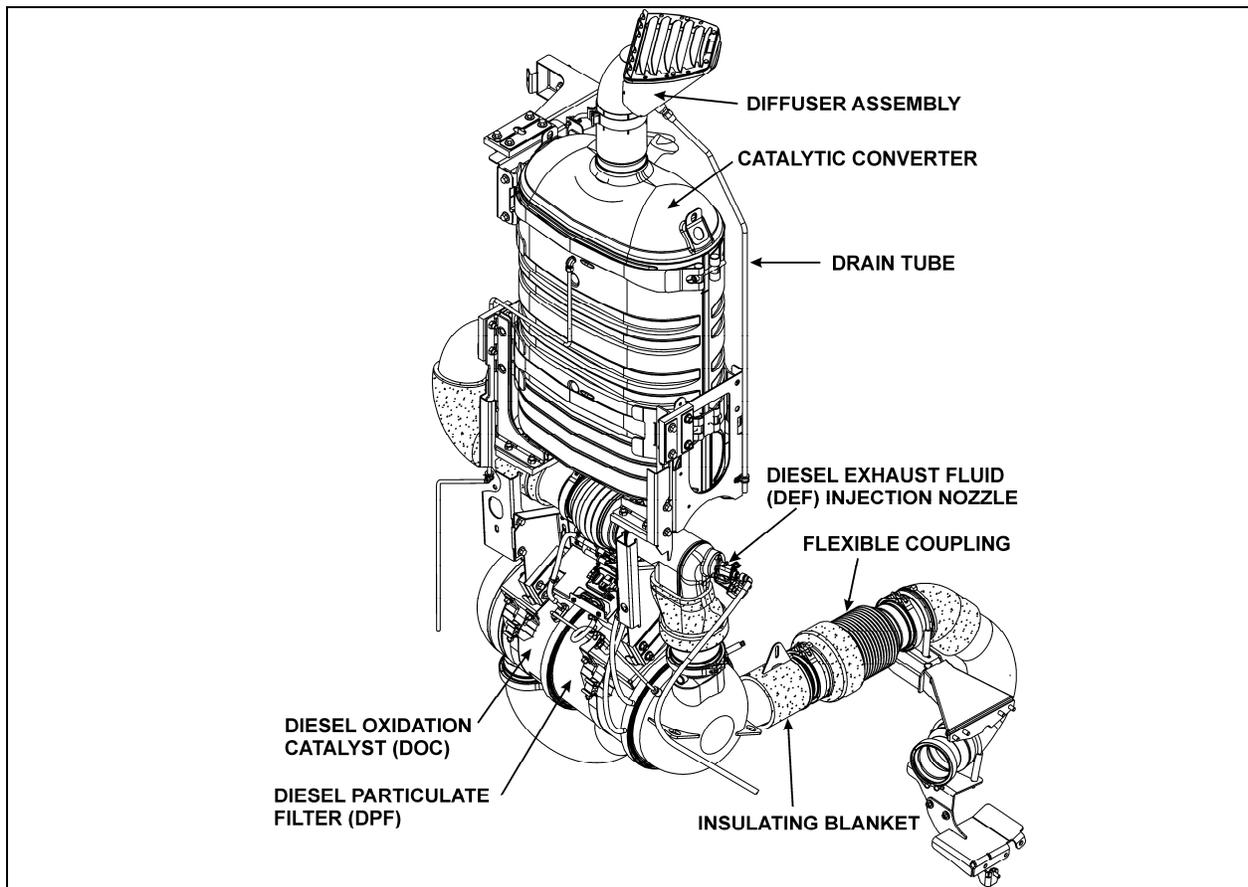


FIGURE 1: EXHAUST SYSTEM

The technology behind clean emissions is through the immediate aftertreatment of engine exhaust. The process for reducing NO<sub>x</sub> via aftertreatment is called Selective Catalytic Reduction (SCR). It requires a catalytic converter into which is injected Diesel Exhaust Fluid (DEF). The primary component of DEF is water; the active component is urea. Urea is a nitrogen compound that turns to ammonia when heated. When a urea-and-water solution is injected into the exhaust stream and passed over a catalyst, the urea reacts with the NO<sub>x</sub> to form nitrogen and water vapor – two clean and harmless components of the air we breathe. The aftertreatment system primary function is to capture and oxidize (regenerate) the particulate matter (soot) in the engine exhaust gases and to reduce NO<sub>x</sub>. To achieve this goal, the exhaust aftertreatment system is split into two main sections: the exhaust gases first enter the **Diesel Oxidation Catalyst (DOC)** and **Diesel Particulate Filter (DPF)** assembly to capture

and regenerate the soot on a regular or passive basis, then the exhaust gases flow through the **catalytic converter** to reduce NO<sub>x</sub> to minimum level. Through constant monitoring of the exhaust gas temperature and the system back pressure, the Engine Monitoring System (EMS) is able to manage regeneration.

The exhaust aftertreatment system is rubber mounted to the vehicle structure. This feature reduces the transmission of vibrations to the exhaust aftertreatment system thus resulting in extended life of the system, brackets and also noise reduction.

#### 1.1 MAINTENANCE

Inspect the exhaust system periodically for restrictions and leaks. Figure 1 presents the major components of the exhaust system. Exhaust leaks are commonly the result of loose clamp bolts, corroded or punctured pipes. In

In addition to excessive noise, a leaking exhaust system could allow toxic gases to enter the vehicle. Damage to surrounding components from hot gases could result as well. Replace damaged or corroded exhaust components immediately.

Inspect the exhaust system as follows:

- At vehicle inspection intervals ;
- Whenever a change is noticed in the sound of the exhaust system ;
- When components close to the exhaust system get unnaturally dirty ;
- Whenever the exhaust system is damaged.

Replace damaged or corroded exhaust system components without delay.

When operating the engine in a service garage or in a closed area, the exhaust must be vented to the outside. Place the shop vent hose over the exhaust outlet pipe.


DANGER

Avoid breathing exhaust gases since they contain carbon monoxide which is odorless and colorless but harmful. Carbon monoxide is a dangerous gas that can cause unconsciousness and can be lethal. If, at any time you suspect that exhaust fumes are entering the vehicle, locate and correct the cause(s) as soon as possible.

**NOTE**

*The key to successful regeneration is high exhaust temperature for an extended period of time. For this reason, insulating blankets must remain permanently on the exhaust system.*

*If insulating blankets are removed from the system, the exhaust gases temperature may not be high enough to permit efficient particulate oxidation during passive regeneration, resulting in increased fuel consumption due to overuse of active or stationary regeneration.*

### 1.2 FLEXIBLE COUPLING INSTALLATION

The flexible coupling contains a rigid interior pipe (Fig. 2). To allow appropriate flexibility once installed, be sure interior pipe is concentric to flexible part and that the flexible coupling is

straight when installed. This piece of equipment handles vibration and thermal expansion.



## CAUTION

Adequately support the exhaust system line. The load of the exhaust line **must not** be transferred to the turbocharger.

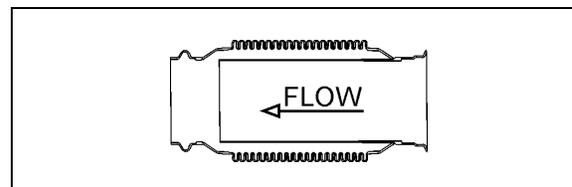


FIGURE 2: FLEXIBLE COUPLING 04022

## 2. DIESEL PARTICULATE FILTER (DPF)

Besides trapping soot, the **DPF (Diesel Particulate Filter)** also traps the ash that has been generated when additives in engine oil are burned. However, unlike soot, ash cannot be oxidized. The ash that accumulates in the filter will eventually cause an increase in exhaust back pressure. EMS will constantly monitor the ash accumulation and forecast the approximate time until DPF ash cleaning is required. This allows you the opportunity to plan for the DPF ash cleaning interval. If ash cleaning is not performed proactively, and the back pressure increases beyond the system limit, EMS will flag the amber warning light on the telltale panel, notifying the operator that an ash cleaning is required. Clean remanufactured DPF cartridge will be available through Prevest on an exchange basis. For most vehicle applications and duty cycle, this will occur after approximately 200,000-400,000 miles (320,000-640,000 km) of operation.



## WARNING

### HOT SURFACES

Keep yourself clear of hot Aftertreatment System surfaces, particularly during and after active or stationary regeneration. Hot surfaces can cause serious burns.

Make sure Aftertreatment System components are cold before handling.

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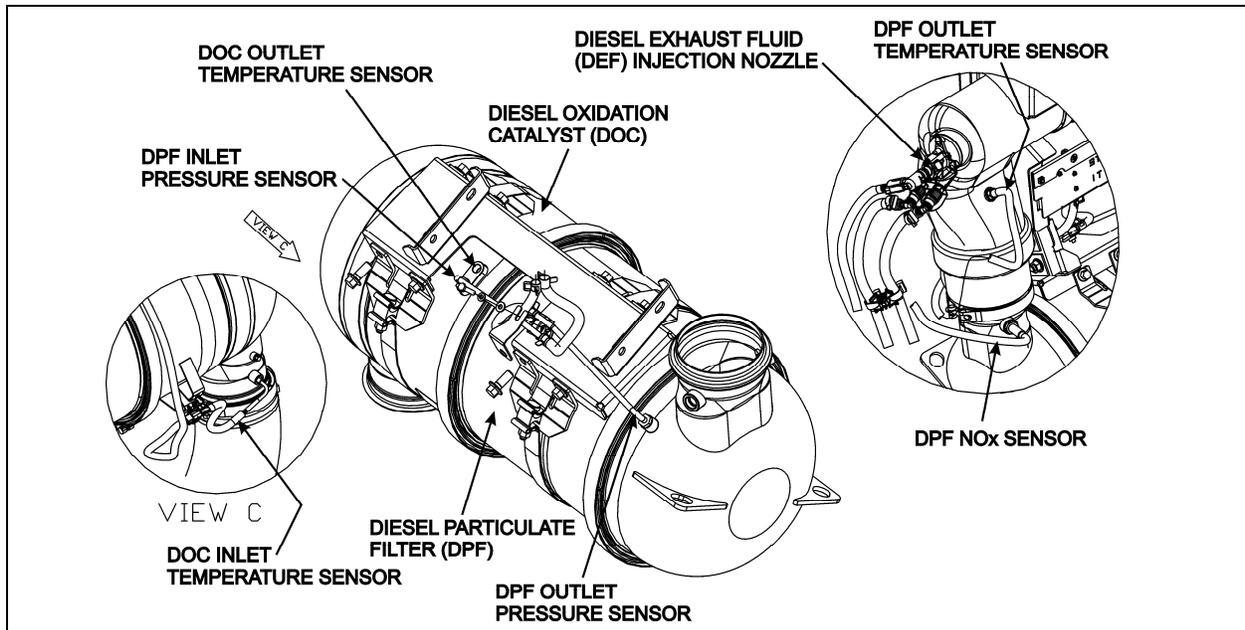


FIGURE 3: DIESEL OXIDATION CATALYST (DOC) & DIESEL PARTICULATE FILTER (DPF) ASSEMBLY 04016



### WARNING

#### HOT EXHAUST

During stationary regeneration, exhaust gases temperature may get very hot at the diffuser outlet. Do not direct diffuser at combustible materials. Before initiating stationary regeneration, make sure that the diffuser outlet is clear of objects and that no one is working near the diffuser outlet. Stationary regenerations must be undertaken outdoors only.

**Never** initiate regeneration when exhaust gas collection system is in place.



### WARNING

#### TOXICITY

Do not initiate a stationary regeneration in a closed area like a garage. **Stationary regeneration must be undertaken outdoors only.**

### 2.1 DIESEL PARTICULATE FILTER ASSEMBLY REMOVAL

To remove the DPF, proceed as follows:



### CAUTION

External and internal temperatures remain hot long after engine has been shutdown. Allow the Exhaust Aftertreatment System to cool before handling. Wear protective clothing and glove while servicing.

1. First, open the engine compartment door;
2. Put insulating blanket aside;
3. Disconnect pressure, NOx and temperature sensors;
4. Support Diesel Oxidation Catalyst (DOC) and Diesel Particulate Filter (DPF) assembly;



### CAUTION

#### HEAVY DEVICE

A suitable lifting or holding device is required. Properly support and attach lifting equipment to prevent the DOC and DPF assembly from falling when servicing.

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5. Unfasten clamps holding DOC and DPF assembly;
6. Carefully lower DOC and DPF assembly;
7. To make sure components are reinstalled in the same position, mark position of DOC, DPF and clamps in relation with one another before taking apart;



### CAUTION

#### FRAGILE - HANDLE WITH CARE

Use extreme care when handling DPF cartridge as it could be damaged or destroyed by dropping or sudden impact.

Clean remanufactured DPF filtration cartridge will be available on an exchange basis. For this reason, it is very important to maintain the cartridge in perfect condition. Damaged cartridge may not be refunded.

8. Also replace V-band clamps and gaskets when replacing DPF filtration cartridge;

#### NOTE

When replacing the DPF cartridge, refer to the specifications on the DPF attached tag for proper replacement DPF selection.

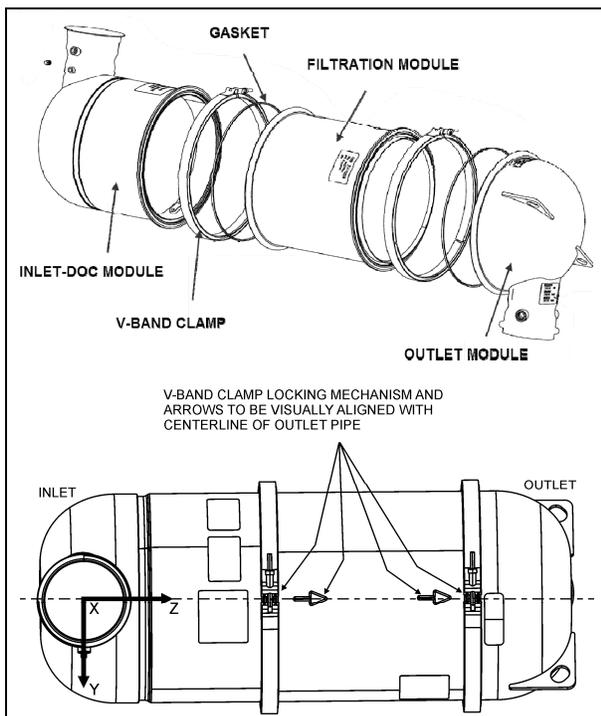
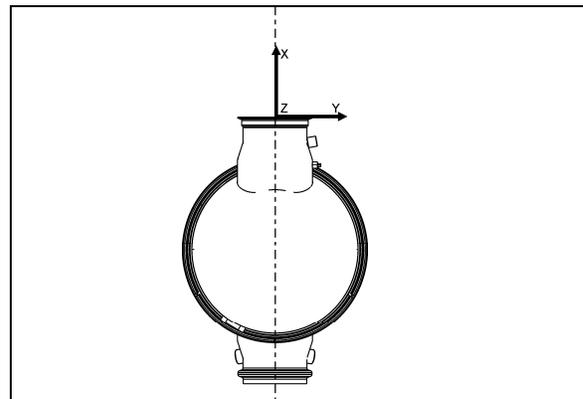


FIGURE 4: TAKING DOC AND DPF APART

9. Always put DOC and DPF filtration cartridge back together again in a vertical position to facilitate gaskets positioning;



10. Torque V-band clamps to 20 lbf-ft (27 Nm) by hand;



### CAUTION

Always torque clamps by hand.

11. With a rubber mallet, hit clamps forcefully around circumference to make sure gasket is fully seated;
12. Support Diesel Oxidation Catalyst (DOC) and Diesel Particulate Filter (DPF) assembly during reinstallation;
13. Reconnect pressure, NOx and temperature sensors;
14. Fasten straps holding DOC and DPF assembly;
15. Put insulating blanket back.

### 3. CATALYTIC CONVERTER

In the first instance, the catalytic converter of the Selective Catalytic Reduction (SCR) does not need any maintenance. Unless an accident or damage occurs in the vicinity of the engine compartment; the catalytic converter will not have to be replaced.

However if the catalytic converter must be replaced, use one of the two following procedures:

#### 3.1 REMOVAL

##### Procedure # 1

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Radiator must be removed in order to lower the catalytic converter for replacement.

- Set the starter selector switch to the *OFF* position.
- Shut off the heater line shut-off valves.
- Using the quick-connect drain hose, drain the engine cooling system. Refer to Section 05, COOLING under "DRAINING COOLING SYSTEM".



### CAUTION

Tag hoses and cables for identification before disconnecting in order to facilitate re-installation. Plug all openings to prevent dirt from entering the system.

- Disconnect and remove section of coolant pipe assembly mounted between the radiator outlet and the water pump inlet.

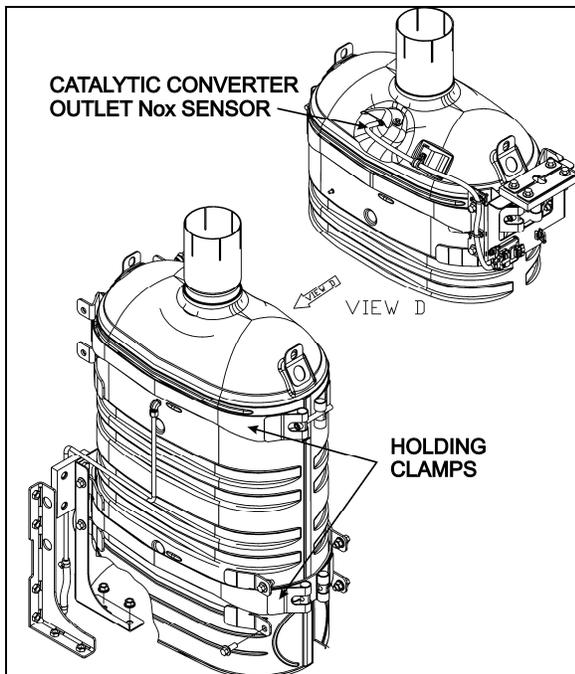


FIGURE 5: CATALYTIC CONVERTER

- Disconnect and remove a section of coolant pipe assembly mounted between the thermostat housing and the radiator inlet.
- Disconnect the electric fan-clutch connector located near the cooling fan right angle gearbox.
- Disconnect and remove the air intake duct mounted between the turbocharger outlet and the air cooler inlet.

- Open radiator door. Unfasten bolts and screws fixing radiator sealing frame.
- Remove radiator and air cooler assembly.



### WARNING

Due to the heavy load of the radiator assembly, it must be adequately supported before attempting to remove it.

- Safely support catalytic converter from the top.
- Disconnect catalytic converter outlet NOx sensor.
- Remove clamps holding catalytic converter then lower.
- Remove or disconnect any piece of equipment or component that might be in the way or that might prevent removing the catalytic converter.

### Procedure # 2

- Set the starter selector switch to the *OFF* position.
- Shut off the heater line shut-off valves.
- Remove DOC and DPF assembly (Refer to paragraph 2.1 in this Section).
- Remove pipe connecting DOC & DPF assembly to catalytic converter.
- Using the quick-connect drain hose, drain the engine cooling system. Refer to Section 05, COOLING under "DRAINING COOLING SYSTEM".



### CAUTION

Tag hoses and cables for identification before disconnecting in order to facilitate re-installation. Plug all openings to prevent dirt from entering the system.

- Disconnect and remove section of coolant pipe assembly mounted between the radiator outlet and the water pump inlet.
- Disconnect and remove a section of coolant pipe assembly mounted between the thermostat housing and the radiator inlet.

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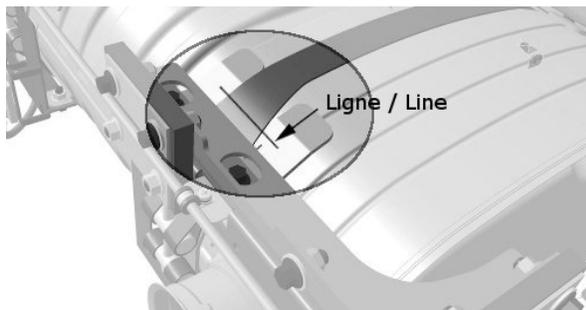
- Disconnect and remove the air intake duct mounted between the turbocharger outlet and the air cooler inlet.
- Remove coolant surge tank.
- Release tension from drive belt (Refer to paragraph 12.1 and 15.1 in Section 05: Cooling System).
- Cut cable ties and disconnect electrical connector from fan clutch. Remove fan drive shaft fasteners at the gear box.
- Remove radiator fan drive mechanism support.
- Safely support catalytic converter from the top.
- Disconnect catalytic converter outlet NOx sensor.
- Remove clamps holding catalytic converter then lower.
- Remove or disconnect any piece of equipment or component that might be in the way or that might prevent removing the catalytic converter.

### 3.2 ASSEMBLING CATALYTIC CONVERTER

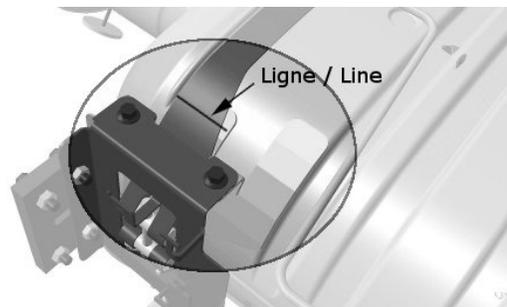
#### Before removing

- Mark, with a vertical line the angular position of the lower (both sides) and upper clamps with regard to the clamps support located on the catalytic converter.

Lower

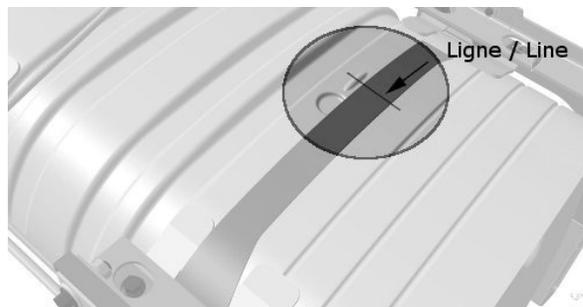


Upper

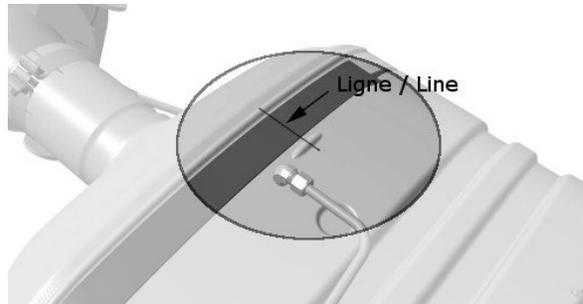


- Mark, with a vertical line the central position of the lower and upper clamps with regard to the emboss located at the bottom and at the top of the catalytic converter.

Lower



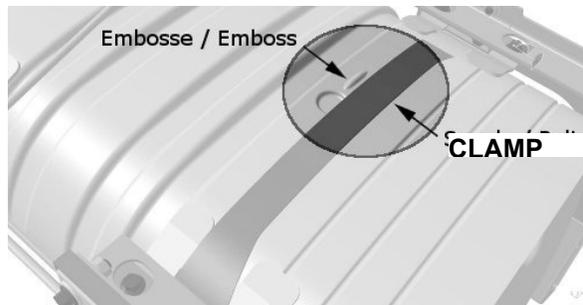
Upper



#### Assembling

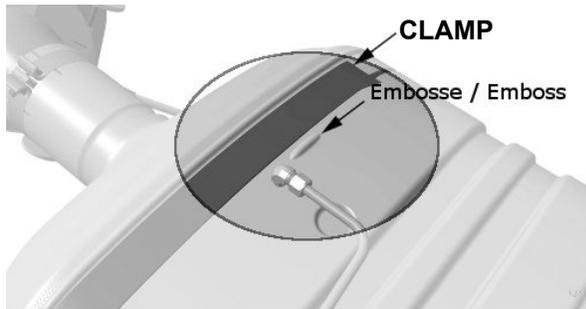
- Position the upper clamps above the upper emboss and the lower clamps below the lower emboss of the catalytic converter.

Lower



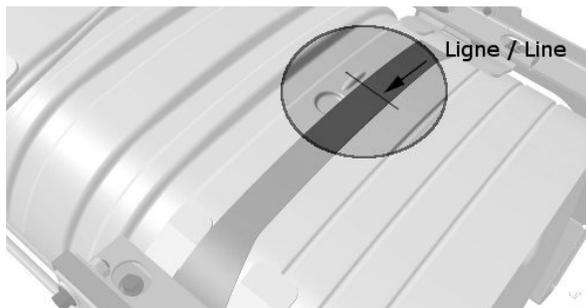
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Upper

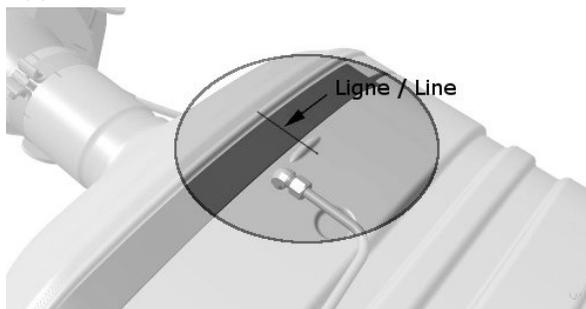


- Using the lines made earlier, line up the lower and upper clamps with regard to the emboss of the converter and afterward, line up the lines made earlier on the clamps with regard to the clamp supports on the catalytic converter.

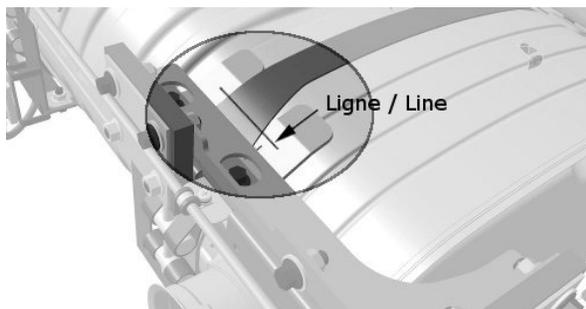
Lower



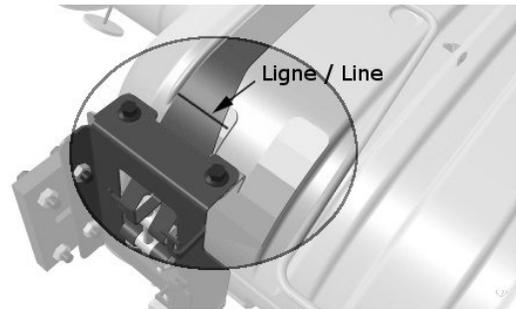
Upper



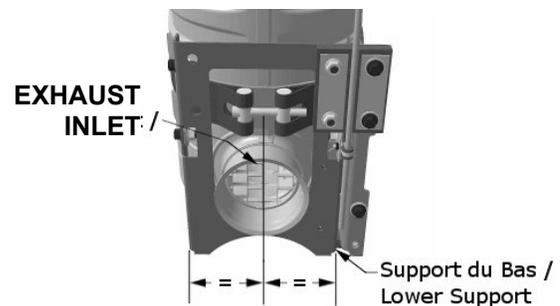
Lower



Upper



- Before tightening the parts, make sure that the catalytic converter lower support is well centered with the exhaust inlet of the catalytic converter.



- While tightening the bolts, keep in mind to respect the alignment of the parts and keep the lower support as centered as possible with the catalytic converter exhaust inlet.

### 4. DIFFUSER ASSEMBLY

During stationary regeneration, exhaust gases temperature may get very hot at the SCR outlet. The diffuser decreases the exhaust gasses temperature by about half approximately, at 6 inches above the diffuser. The diffuser is an important component of the exhaust system and must remain on the vehicle at all times. Operating the vehicle without the diffuser may seriously damage the vehicle.

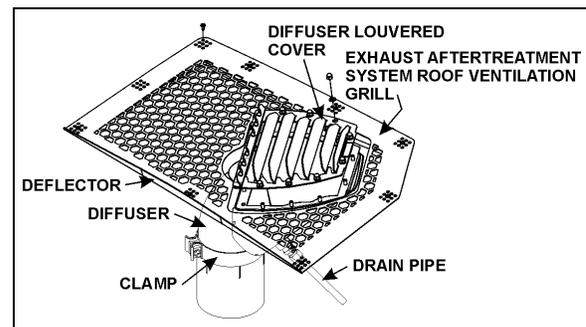


FIGURE 6: DIFFUSER ASSEMBLY

04014

4.1 DIFFUSER ADJUSTMENT

Should an adjustment of the diffuser position be necessary, first remove the exhaust aftertreatment roof ventilation grill.

**CAUTION**

To prevent paint damage and fiberglass overheating caused by hot exhaust gases, the diffuser louvered cover must be flush with the roof surface or may not exceed the roof surface more than 3/32 inch (2 mm).

**CAUTION**

Tighten clamps properly in order to prevent any movement of the diffuser assembly. An impact wrench is necessary.

1. Loosen the clamp securing the diffuser assembly to the catalytic converter.

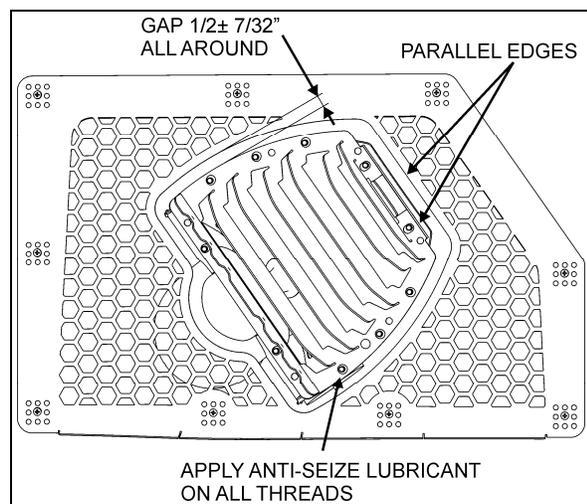


FIGURE 7: DIFFUSER POSITION ADJUSTMENT 04015\_1

2. For proper angular position, make sure that the two edges shown on figure 7 are parallel with each other.
3. Using a straightedge, adjust the diffuser assembly level. The top surface of the warning plate fixed on the diffuser louvered cover must be flush with the roof surface or may exceed about 3/32in (2mm).
4. Tighten the clamp securing the diffuser assembly to the catalytic converter.
5. Reinstall the exhaust aftertreatment system roof ventilation grill and deflector.

4.2 MAINTENANCE

At vehicle inspection intervals, inspect the diffuser assembly as follows:

- Inspect diffuser grille for stress cracking;
- Check for presence of foreign matter and debris inside the diffuser housing, remove and clean if applicable;
- Check for proper functioning of the rain cap inside the diffuser housing, make sure that it moves freely;
- Make sure that the water drain tube is not clogged. Pour a cup of water into the diffuser housing and assure that all the water is drained at once at the other end of the drain tube. If tube is clogged, remove tube and blow compressed air inside, in reverse flow;
- Check that the warning plate "THIS DIFFUSER SURFACE MUST BE FLUSH WITH THE ROOF SURFACE" is still in place.

4.3 DIFFUSER EXTENSION – VIP

A diffuser extension is available for converters. To install:

1. Remove the existing diffuser louvered cover;
2. Mount the extension on the diffuser housing. Secure with the 10 existing cap nuts;
3. Slide the heat shield over the extension;
4. Place the diffuser louvered cover over the assembly and secure with a second set of 10 identical cap nuts.

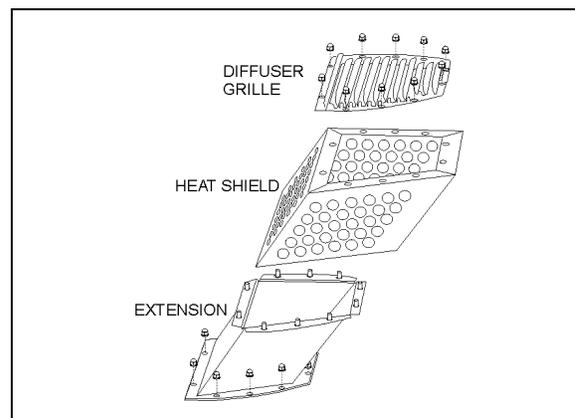


FIGURE 8: DIFFUSER EXTENSION 04021

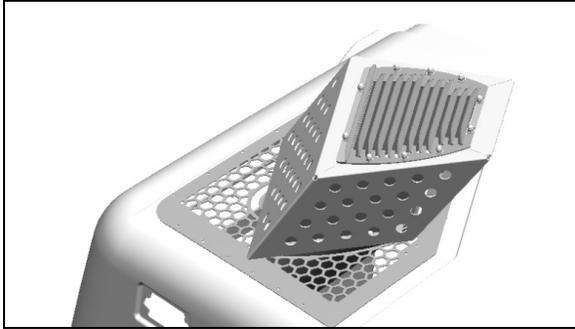


FIGURE 9: DIFFUSER EXTENSION FOR MOTORHOMES

## 5. DIESEL EXHAUST FLUID (DEF) TANK AND INJECTION SYSTEM

The DEF tank and injection system control unit continuously vary the amount of DEF injected in response to the engine's current load conditions.

Diesel Exhaust Fluid (DEF) is stored in a 16 gallons (60 liters) plastic tank located in the condenser compartment, behind the condenser – ventilation fan assembly.

A pump located beside the DEF tank is used to pressurize the system and deliver the fluid.

A heating coil located inside the tank use engine coolant to keep the DEF in a liquid state or to melt DEF at engine start up during cold season.

DEF is injected into the exhaust gases through an injection nozzle located between the DPF and the catalytic converter (refer to figure 1).

In the catalytic converter, nitrogen oxides are transformed into harmless nitrogen gas and water.

The system notifies the driver when it is time to top up with DEF.

### 5.1 DIESEL EXHAUST FLUID

When handling DEF solution, it is important that electrical connectors to be connected or well encapsulated, otherwise there is a risk that the DEF will cause oxidation that cannot be removed. Water or compressed air will not help, since DEF quickly oxidizes certain metals. If a disconnected connector comes into contact with the DEF solution, it must be replaced immediately to prevent the DEF solution from creeping further into the copper wiring, which takes place at a speed of about 2.4 in (60 mm) per hour.



## CAUTION

Diesel Exhaust Fluid (DEF) is a nontoxic aqueous solution of urea (32.5%) and ultra-pure water (67.5%). Urea is a compound of nitrogen that turns to ammonia when heated. The fluid is non-flammable, and is not dangerous when handled as recommended. However, it is highly corrosive to certain metals, especially copper and brass.

When detaching hoses and components, do not spill DEF on disconnected or unsealed connectors. If DEF is spilled on a disconnected or unsealed connector, the connector must be removed immediately and replaced.

Things to know about spilt diesel exhaust fluid (DEF):

- If urea solution comes into contact with the skin, rinse with plenty of water and remove contaminated clothing.
- If urea solution comes into contact with the eyes rinse for several minutes and call for medical help if necessary.
- If inhaled breathe fresh air and call for medical help if necessary.
- Do not allow the DEF solution to come into contact with other chemicals.
- The DEF solution is not flammable. If the DEF solution is exposed to high temperatures, it breaks down into ammonia and carbon dioxide.
- The DEF solution is highly corrosive to certain metals, including copper and aluminum.
- If the DEF solution is spilled onto the vehicle, wipe off the excess and rinse with water. Spilled DEF solution can form concentrated white crystals on the vehicle. Rinse off these crystals with water.



## WARNING

DEF spilt onto hot components will quickly vaporize. Turn your face away!

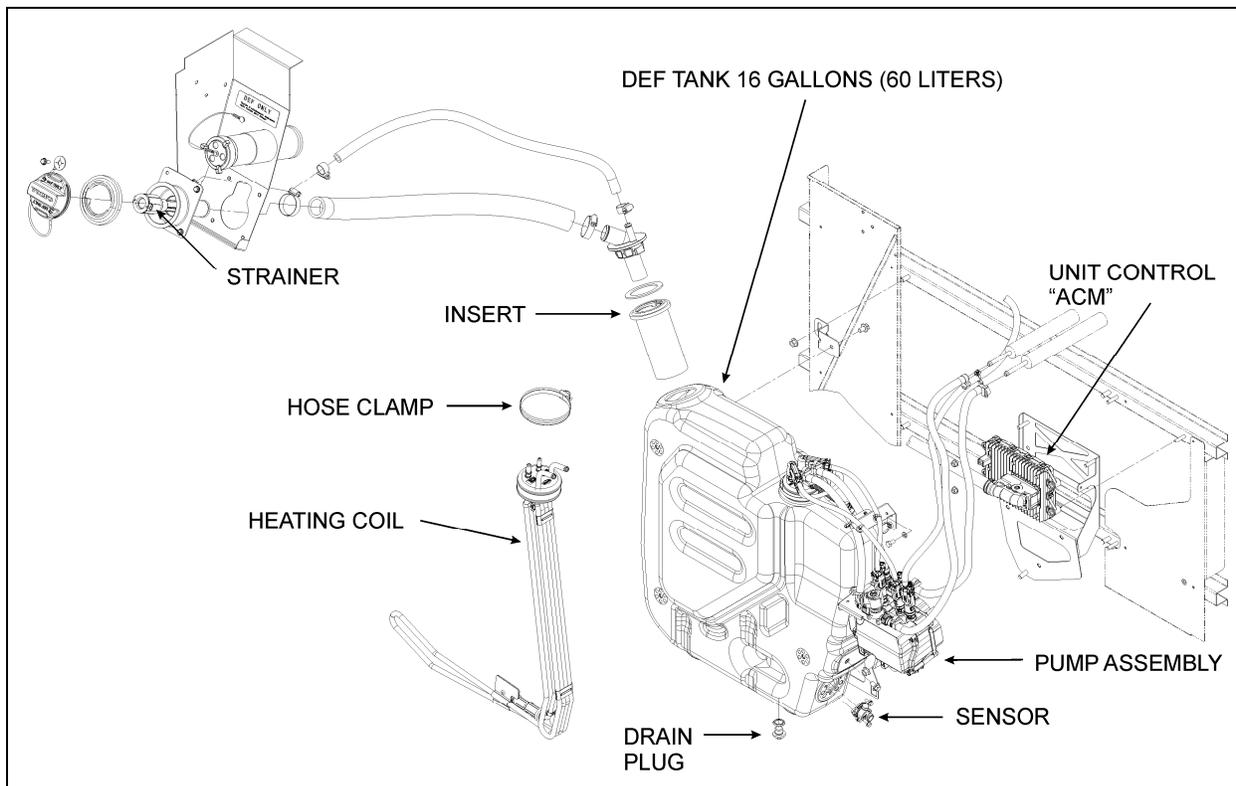
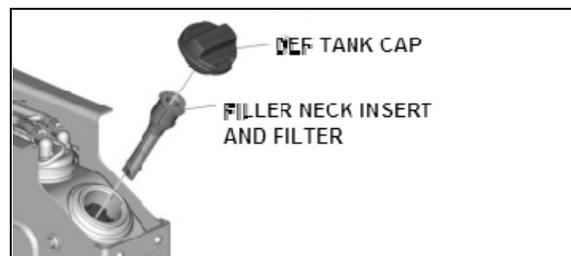


FIGURE 10: DEF TANK AND PUMP LOCATION (INSIDE CONDENSER COMPARTMENT)

### 5.2 DEF TANK CLEANING

Removing the DEF tank for cleaning is not necessary.

1. Put a suitable container under the DEF tank.
2. Remove the DEF tank drain plug through the DEF tank support pan access hole.
3. Let all of the DEF drain from the tank. Discard the used DEF according to local regulations.
4. Remove the DEF tank filler neck insert. To do so, release the retaining tab and remove filler neck insert. Replace old seal if damaged.



5. Flush the tank with hot water. Let all of the water drain from the tank.
6. Clean the filler neck insert screen with hot water.
7. Reinstall the filler neck insert until the retaining tabs snap into filler neck. Reinstall DEF tank drain plug.



### MAINTENANCE

Drain and clean DEF tank and filler neck insert filter with hot water every 175,000 miles or once a year, whichever comes first.

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### 5.3 PUMP ASSEMBLY FILTER ELEMENT REPLACEMENT

1. Clean the area around filter cover.
2. Before you loosen the filter cover, place a suitable container under the cover to catch fluid that may drain from the pump;
3. Remove filter cover.



#### CAUTION

Contamination or damage of the sealing surface on the housing is not acceptable.

4. Use needle nose pliers to carefully remove the equalizer and filter element. Do not damage the sealing surface on the housing.

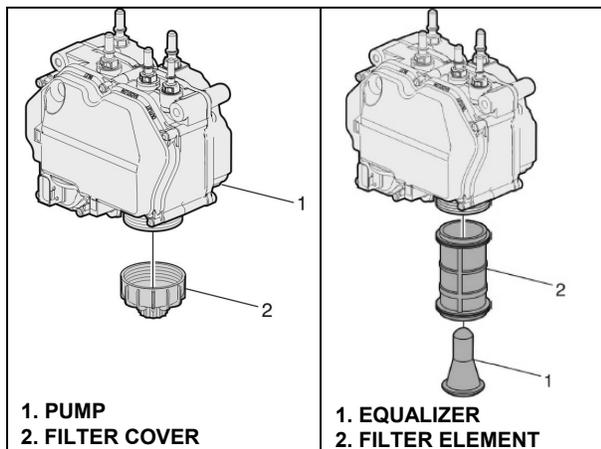


FIGURE 11 : PUMP ASSEMBLY FILTER ELEMENT

5. Install new filter element and equalizer. Checks filter element cover and housing for damage. If either the filter or housing is damaged, the damaged part must be changed.
6. Install filter cover. Torque to  $22.5 \pm 2.5$  Nm.



#### CAUTION

Check if there are cracks around the area of the filter cover. No cracks in the material are allowed.



#### MAINTENANCE

Replace DEF pump filter element and equalizer every 150,000 miles (240 000 km) or 36 months, whichever comes first.



#### MAINTENANCE

Drain and clean DEF tank with water once a year. Clean DEF tank filler neck strainer once a year.

### 5.4 FILLER NECK STRAINER

If the DEF tank filler neck strainer (figure 10) becomes obstructed with foreign matter and debris, remove and clean strainer as follows;

1. Remove filler neck cap.
2. Release the retaining tabs and remove filler neck strainer from the filler neck. Discard the old seal.
3. Clean and reinstall strainer into DEF tank filler neck with new seal.
4. Insert until the retaining tabs snap into the filler neck.

### 6. AFTERTREATMENT FUEL INJECTOR

Proper functioning of the aftertreatment fuel injector a.k.a. aftertreatment hydrocarbon injector (AHI) is required in order to obtain efficient regeneration process of the DPF. Clogged aftertreatment fuel injector will result in clogged DPF.

In addition to the activation of the CHECK telltale, emission of diagnostic troubleshooting codes (DTC) by the engine ECM (MID128) will indicate malfunction of the aftertreatment system and/or aftertreatment fuel injector. DTC may be accessed through the Driver Information Display. Select DIAGNOSTICS menu then FAULT DIAGNOSTICS and ENGINE ECU submenus.

Check status of the aftertreatment system through the Driver Information Display. Select AFTERTREATMENT menu then ATS STATUS. Then check the DPF soot level with SOOT LEVEL GAUGE.

### 6.1 REPLACEMENT

1. Remove fastener and p-clamp securing the line to the mounting bracket on the diffuser pipe.

	<b>WARNING</b>
Fuel leaked or spilled onto hot surfaces or electrical components can cause a fire and result in component damage and serious personal injury.	

2. Disconnect the line from the aftertreatment hydrocarbon injector fitting. Collect any residual fuel that might be in the line in a suitable container.

	<b>CAUTION</b>
Do not kink the line. Kinking the line may result in leakage.	

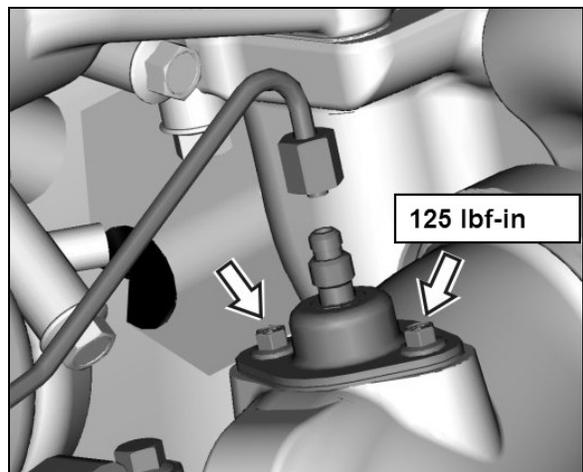


FIGURE 12: AFTERTREATMENT FUEL INJECTOR

3. Remove the aftertreatment hydrocarbon injector mounting fasteners. Remove the aftertreatment hydrocarbon injector from the diffuser pipe (which attaches to the turbocharger outlet).
4. Clean the sealing surface on the diffuser pipe before mounting the aftertreatment hydrocarbon injector.
5. Install the aftertreatment hydrocarbon injector onto the diffuser pipe (which attaches to the turbocharger outlet). Tighten the fasteners to **125 lbf-in**.

<i><b>NOTE</b></i>
<i>The fasteners already include pre-applied high-temperature anti-seize compound.</i>

6. Connect the line to the aftertreatment hydrocarbon injector. Tighten the line fitting to **135 lbf-in**.

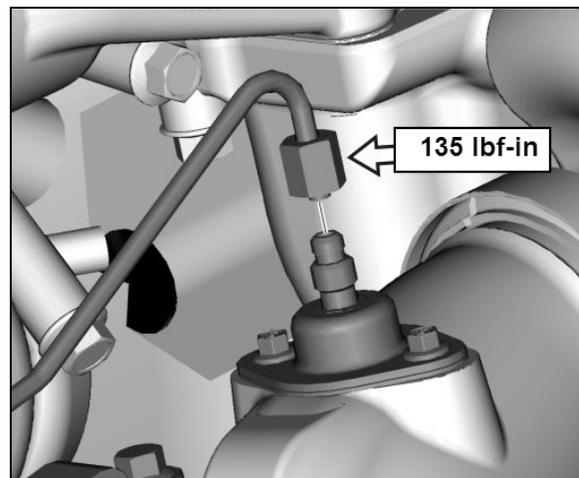


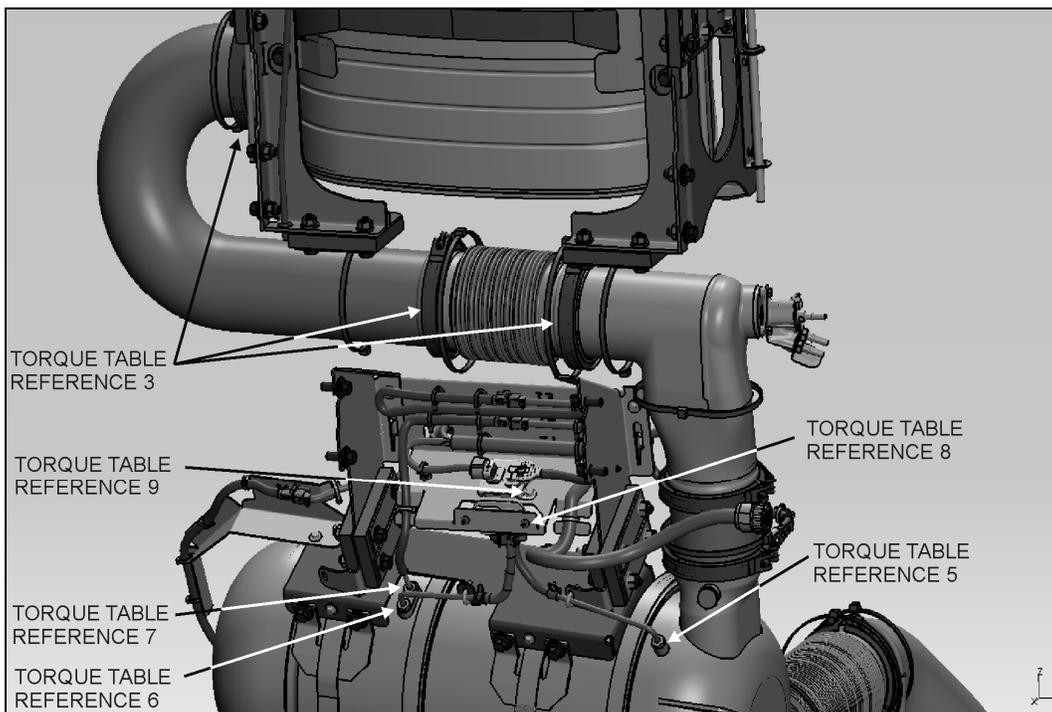
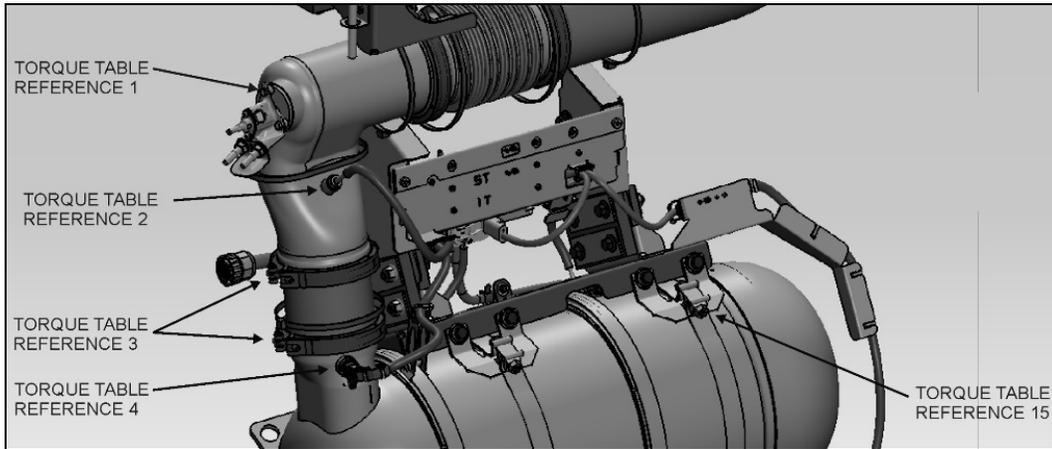
FIGURE 13: FUEL LINE FITTING

7. Install the P-clamp and fastener to secure the line to the mounting bracket on the diffuser pipe.
8. Start the service regeneration process. When fuel dosing starts, check for leaks starting on the hot side of the engine. Clear any diagnostic trouble codes, if needed.

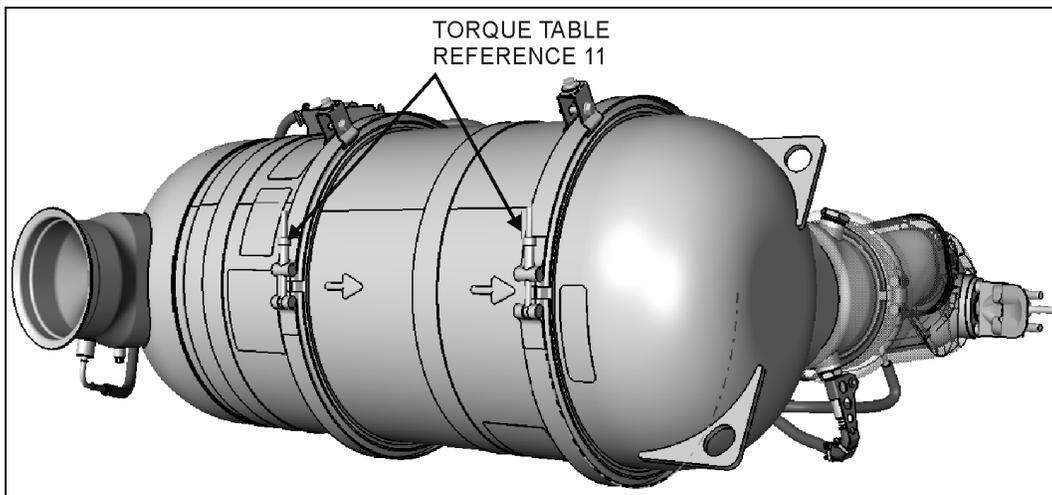
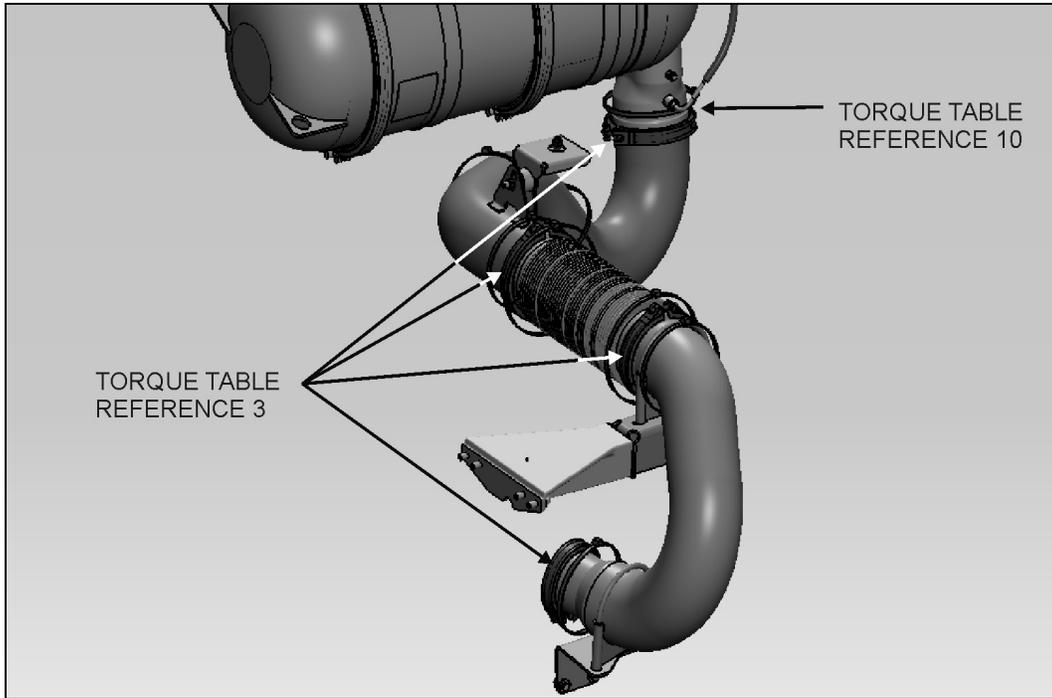
<i><b>NOTE</b></i>
<i>If fault tracing was performed using Guided Diagnostics, return to Guided Diagnostics for repair verification.</i>

## Section 04: EXHAUST AND AFTERTREATMENT SYSTEM

### 7. TORQUE SPECIFICATIONS

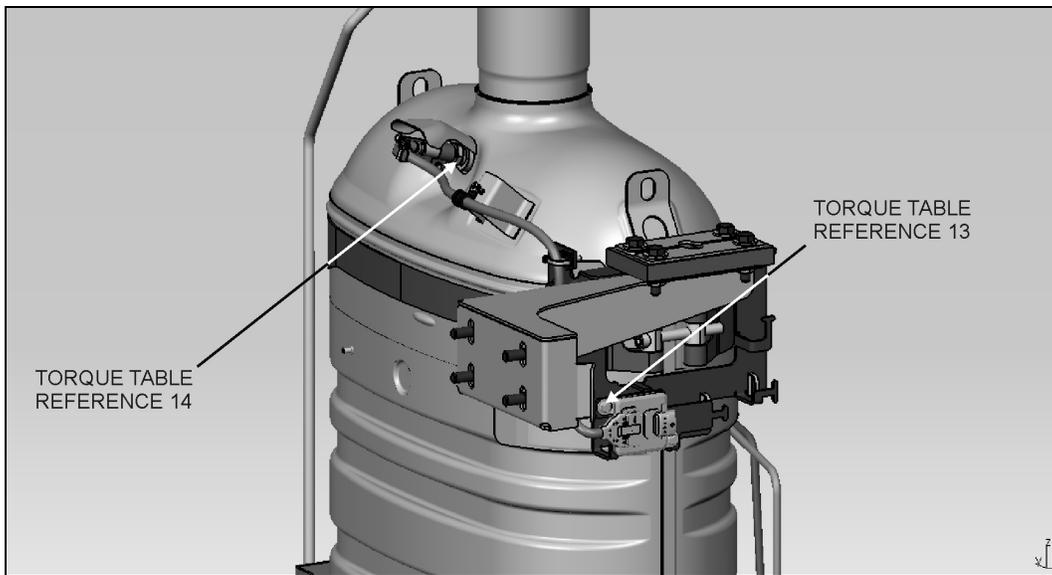
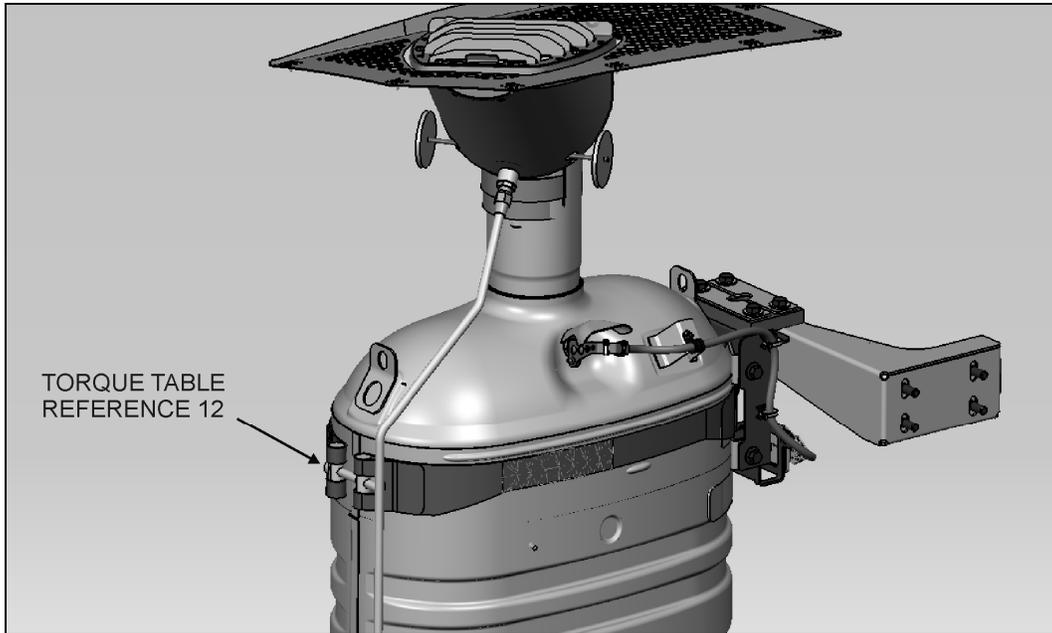


**SECTION 04: EXHAUST AND AFTERTREATMENTSYSTEM**



**Section 04: EXHAUST AND AFTERTREATMENT SYSTEM**

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## SECTION 04: EXHAUST AND AFTERTREATMENT SYSTEM

The following table lists the tightening torques for the bolts, nuts, etc. on the DPF assembly which do require a specific torque value. When no torque specifications are indicated, use the Standard Torque Specifications table found in Section 00: General Information of the Maintenance Manual.

<b>SPECIFIC TORQUE TABLE</b>			
<i>DESCRIPTION</i>	<i>QTY</i>	<i>REFERENCE</i>	<i>TORQUE DRY (lbf-ft)</i> <i>Tolerance: ±10%</i>
<i>DEF injection nozzle mounting bolt</i>	3	1	7.5
<i>DPF outlet temperature sensor *</i>	1	2	33
<i>V-band clamp 4-inch &amp; 5-inch</i>	9	3	8
<i>NOx sensor *</i>	1	4	37
<i>DPF outlet pressure sensor *</i>	1	5	4
<i>DPF inlet pressure sensor *</i>	1	6	4
<i>Diesel Oxidation Catalyst (DOC) temperature sensor *</i>	1	7	33
<i>Cap screw</i>	2	8	4.5
<i>Cap screw</i>	-	9	7.5
<i>DPF inlet temperature sensor *</i>	1	10	33
<i>V-band clamp</i>	2	11	20
<i>Strap – SCR tank</i>	4	12	33
<i>NOx sensor – SCR tank</i>	1	13	37
<i>Bolts – SCR tank</i>	2	14	7.5
<i>Strap – DPF tank</i>	2	15	20

\* Use Permatex 454G anti-seize lubricant or Loctite 76764 silver grade anti-seize